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ON
AN ANTIDOTE AT ONCE FOR PRUSSIC
ACID, ANTIMONY, AND ARSENIC.

BY
MESSRS. T. AND H. SMITH.

ON AN ANTIDOTE AT ONCE FOR PRUSSIC ACID, ANTIMONY, AND ARSENIC.

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Notwithstanding the great number of years that have elapsed since the publication, in the 'Lancet,' of our paper containing an account of a method for counteracting the poisonous action of prussic acid when taken into the living stomach, and the favourable recognition it has received from the most eminent toxicologists, we are not aware of an instance in which it has had any application to the saving of life, except in a case which occurred in our own experience, when, by our prompt supply of the antidote, the life of a lady was no doubt saved. She had swallowed a solution of cyanide of potassium in mistake for a solution of muriate of morphia, both these solutions being in her bedroom, and properly labelled. No bad effects followed the unfortunate mistake. Our experiments on dogs, detailed in our paper in the 'Lancet,' proved beyond a doubt that this antidote is complete and certain. The dogs that got the poison without the antidote died. The dogs that got the antidote after the poison, lived and did well. In all cases, a much larger dose than a merely dangerous one was given, and no prussic acid could be recovered, by distillation, from the stomachs of the dead dogs. Cases of poisoning by prussic acid are frequent enough; but death takes place with such frightful rapidity, that this antidote is almost sure to be unattainable within the brief period in which it could be at all of any service; and that more especially, because the antidote requires to be expressly prepared; its being in readiness for a contingency which may never occur, not being likely, except with ourselves, and, perhaps, one or two others. While thinking over this matter, it has occurred to us, that in liquor ferri perchloridi of the British Pharmacopœia, a remedy may be found for the obstacles that have hitherto existed to the use of the prussic acid antidote. We proceed to show that the time taken to supply the antidote need not be greater than would be necessary to weigh out and measure two or three articles always at hand. The principle of the action of the antidote is exceedingly simple and easily understood; at least, if certain theoretical views be put aside, and the reaction with prussic acid be merely considered as a simple case of double decomposition, which results in the formation, in the stomach, of the harmless compound known as Prussian blue. The formula of Prussian blue is $2(\text{Fe}_2, \text{Cy}_3) + 3(\text{Fe}, \text{Cy})$; showing that 7 equivalents of iron and 9 equivalents of cyanogen are contained in one equivalent of the compound. To produce this compound with the prussic acid there are required 7 equivalents of iron in the form of a soluble compound, of which four equivalents must be in the state of persalt, and 3 equivalents in the state of protosalt. The ready means of obtaining this solution are supplied in the liq. ferri perchloridi, and protosulphate of iron or green vitriol. It is easy to find the quantity of the perchloride solution, containing in grains, 4 equivalents of iron. 2 ounces, or 875 grains, are contained in 10 fluid ounces of the solution. Keeping now in mind that 4 equivalents of iron must be in the state of peroxide, or perchloride, which is equi-

valent; the quantity of perchloride solution required in the production of an equivalent of Prussian blue, may be found without any difficulty, thus:—

Grs. Iron. Fl. oz. Sol. 4 eq. Iron. Fl. oz. Sol.

875 : 10 :: 112 : 1·28, or 614 minims.

The 3 equivalents of iron in the form of protosalt, required for the formation of Prussian blue, are supplied as sulphate of protoxide of iron, the equivalent of which is 139; multiplying that number by 3, gives 417 grains.

It must be quite clear, therefore, that 614 minims of solution of perchloride of iron, and 417 grains of green vitriol, supply the iron in the form and quantity necessary for the production of Prussian blue; and as these ingredients contain, respectively, 6 equivalents of chlorine and 3 equivalents of sulphuric acid (which in Prussian blue are replaced by 9 equivalents of prussic acid), it is evident, as the equivalent of prussic acid is 27, that 9 times that sum is 243; 243 grains of prussic acid can, consequently, be destroyed by the above quantities; therefore, the hundredth of that quantity, or 2·4 grains (a good deal more than 100 minims of medicinal prussic acid), can be destroyed as a poison by 6·14 minims of solution of perchloride of iron, and 4·17 grains of green vitriol; but we need hardly say that prussic acid can take the place of neither hydrochloric nor sulphuric acid, unless, at the same time, an equivalent quantity of a strong base is supplied, to take the strong acid from the iron, the affinity of which is comparatively weak. Under such circumstances, the iron at once seizes on the prussic acid, and the desired result is obtained,—the formation of a harmless and stable compound. The effect is instantaneous.

The base that appears the most suitable for use with the antidote is carbonate of soda, or common washing soda,—but in clean crystals. This substance is very easily obtainable, is the most uniform in condition, and the least liable to adulteration. The quantity corresponding to the iron solution, in order to yield with prussic acid an equivalent of Prussian blue, is 9 equivalents, for there are 6 equivalents of hydrochloric acid, and 3 equivalents of sulphuric acid, which, therefore, in combining with the soda, gives 6 equivalents of chloride of sodium and 3 equivalents of sulphate of soda; and if there should have been a quantity of prussic acid in the stomach equal to 9 equivalents, the whole of the iron would have been converted into Prussian blue; but if the quantity of prussic acid should have been equal to $4\frac{1}{2}$ equivalents, or, say half that quantity, the half or the quarter of the iron would have been changed into Prussian blue, and the remainder into protosessquioxide of iron, a compound which may be taken inwardly without bad effects. The equivalent of crystallized carbonate of soda, not effloresced, is 143, nine times that quantity is 1287, and the hundredth part is consequently 12·87. The antidote for 2·4 grains anhydrous prussic acid, or upwards of 100 minims of medicinal prussic acid, is therefore theoretically 6·14 mins. liq. ferri perchloridi and 4·17 grs. green vitriol, mixed together in one solution, and another solution containing 12·87 grs. crystallized carbonate of soda. But we would recommend about six times these quantities for every 100 mins. medicinal prussic acid supposed to have been taken. We would therefore propose to attach to every bottle of sol. ferri perchloridi kept in stock by every druggist, a printed direction such as we append to this paper. For ourselves, we have already put into the printer's hands such directions.

The reason for so large an excess of the antidote to prussic acid being recommended is, that the carbonic acid interferes with the reaction, producing Prussian blue. The affinities of the carbonic and prussic acids for the soda are so nearly balanced that the reaction resulting in Prussian blue is not complete without the presence of a large excess of the iron and carbonated alkaline solution. The result would be very different with the use of a caustic alkali, but its corrosive action and less definite state precludes its use.

When poisoning has been caused by cyanide of potassium, in which the prussic acid is already united to a base, the alkaline solution forming one part of the antidote does not, of course, require to be given, although the antiodotal action would not be prevented by giving it in the way recommended. The only result that would follow giving double the proper quantity of alkali would be the formation of yellow prussiate of soda and protosesquioxide of iron by the decomposing action of the carbonate of soda on the Prussian blue first formed. The yellow prussiate of an alkali is known to be a comparatively very inert substance.

The proof of what has been said is very easy. Take the quantity of a solution of protosesquisalt of iron, as given for the prussic acid antidote, then add the equivalent quantity of a solution of cyanide of potassium, in order to form Prussian blue. On now adding the quantity of solution of carbonate of soda corresponding to the iron solution, the Prussian blue, on brisk stirring, loses its colour for a greenish-black of protosesquioxide of iron, and, on now filtering, the filtrate reproduces Prussian blue on the addition of a persalt of iron.

The solution of perchloride of iron also supplies the means of obtaining instantaneously Bunsen's antidote for arsenious acid. When this idea first occurred to us, we intended to try in what time the hydrated peroxide could be thrown down, washed, and got into a state for exhibition to the patient; but on reflection, it appeared quite unnecessary to spend a moment's time more than would be required to measure out the quantity of solution of perchloride of iron, mix it with the alkali, and, after stirring, to give it at once to the patient.

We found that 80 grs. of peroxide of iron in the form of hydrate, obtained by precipitation with carbonate of soda, absorbed 10 grs. arsenious acid from solution. What in this case would have been the result, supposing this had been an actual case of poisoning with arsenious acid? 80 grs. of peroxide of iron, in the form of perchloride, would have required 3 equivalents, or 432 grs. of carbonate of soda. The result of the double decomposition between the perchloride of iron containing 3 equivalents of chlorine and the 3 equivalents of soda in the carbonate of soda, would have been 3 equivalents of chloride of sodium, or 175.5 grs., *i.e.* less than half an ounce of common salt, which, as an emetic, would actually have assisted the recovery of the patient, and therefore its exhibition along with the antidote could only have acted beneficially.

As we have found by innumerable trials that 80 grs., or 1 equivalent of peroxide of iron, absorbs 10 grs. of arsenious acid, it is necessary to find how much of the solution of the perchloride of iron is required to give that quantity. The calculation is easily made: 80 grs. peroxide of iron contain 56 grs. of iron, and as 10 fluid oz. of the solution contain 2 oz. or 875 grs. of metallic iron, the quantity required is given by the following proportions:— $875 : 10 :: 56 : x = 0.64$. The quantity of the solution of perchloride of iron containing 56 grs. of metallic iron, or 80 grs. of peroxide, is therefore 0.64 oz., or $\frac{1}{25}$ of an oz., or exactly 5 fluid drachms and 7 minims.

The quantity being thus known, when the antidote is required, 307 minims of the solution are to be measured out, mixed with 1 or 2 ounces of water in a measure or beaker, and 1 ounce of crystallized carbonate of soda having been dissolved in about a couple of ounces of warm water, by rubbing up in a clean mortar, it is poured into the solution of iron, and the mixture stirred with a glass rod till the effervescence ceases; the pulpy hydrate is then ready for exhibition.

The moment the antidote has had time to mix with the contents of the stomach, it will have absorbed arsenious acid to the extent of 10 grs. Should

more than that quantity have been taken, it becomes a question how much of the antidote may with safety be given, in the form recommended. It appears to us that a large quantity could be given with perfect safety. If the decision should be different, it would then be necessary to prepare the hydrated oxide of iron in the way recommended by Bunsen, and for the preparation of which there would be abundance of time, on account of the immediate effects of the poison having been effectually counteracted.

The solution of perchloride of iron is admirably adapted for the preparation of the hydrated peroxide. 10 fluid oz. give 1256 grs., or nearly 3 oz. of peroxide. Supposing 3 fluid oz. of the solution be taken to prepare the hydrate; pour this quantity into a convenient vessel for precipitation, a tall precipitating-glass would be best, add from five to ten times its bulk of pure water, then add liquor ammoniæ until, after brisk agitation, it smells distinctly of the volatile alkali; let the precipitate settle; pour off the clear liquid, and mix in a fresh quantity of water; let the precipitate settle a second time, then pour off the liquid as before; after repeating this operation several times, it may be considered sufficiently washed, but it may be better washed by now filtering, and if the hydrate has been thrown down from a warm and concentrated solution (which we have found does not prevent its antidotal action), the washing on the filter is not by any means tedious. The hydrate may easily be got ready for use in about an hour. The hydrate thus obtained is a most effectual antidote, and can be administered safely in almost any quantity.

When we turned our attention to this matter, we were in the belief that the hydrated oxide of iron would only act as an antidote to arsenious acid in the very pulpy state of hydrate, thrown down from very dilute cold solutions of peroxide of iron by ammonia, but we have found that it is of very little consequence, whether the oxide be thrown down from strong or weak, hot or cold solutions or whether by ammonia or a carbonated alkali; if, under any of these circumstances, the hydrate be used before being dried, it is almost equally effectual in absorbing the poison; if, however, the oxide should have been dried, it no longer acts; it does not appear to have the least power of removing arsenious acid from a liquid.

We have found, however, that 100 grs. of dry peroxide of iron, if subjected to most careful pulverization and elutriation, remove rather more than 2 grains of arsenious acid from solution.

The hydrate already prepared, and kept under water for some months, loses its absorbing action gradually (slowly at first, but in an increasing ratio afterwards), so that, after four months, its power is not more than half of what it originally was; and, after five, its absorptive action is diminished to about a fourth.

That we might be able to make a definite statement of the time in which the hydrated peroxide of iron could be precipitated, washed, and made ready for use, we threw down, with excess of ammonia, a quantity of the solution of perchloride of iron, containing 80 grs. of anhydrous peroxide of iron, after mixing it with ten ounces of water at a heat of about 120° F.

The precipitate settled quickly, but we did not wait for subsidence, so as to effect the washing by decantation, but at once threw the whole upon a filter, and washed the precipitate with pure water till the washing water passed through tasteless. The operation was finished in twenty minutes. The drained hydrated oxide was found to weigh exactly $4\frac{1}{2}$ oz. On now mixing, in a beaker, the hydrated oxide thus obtained with 10 grs. of arsenious acid in solution, carefully agitating for a few minutes, and then separating the liquid by filtration, sulphuretted hydrogen water added to the filtered liquid, acidulated with a few drops of muriatic acid, failed to

show the presence of the slightest trace of arsenic. The whole operation was terminated within half an hour.

Three points worthy of special remark are brought out by this experiment:—

1st. The short time required for the preparation of the antidote, the solution of perchloride of iron being always ready at hand.

2nd. The remarkable bulk of the hydrated oxide of iron, in the only state in which it should be used as an antidote for arsenious acid. Although the hydrate used contained only 80 grs. of dry peroxide of iron; yet, in the state of hydrate, the weight was actually $4\frac{1}{2}$ oz. avoirdupois; the oxide of iron retaining a quantity of water equal to twenty-one times its own weight.

3rd. Although the oxide was thrown down at a heat not less than 110° F., yet it was capable of entirely removing 10 grs. of arsenious acid from solution in water.

We have stated that 80 grs. of peroxide of iron, in the form of hydrate, absorb 10 grs. of arsenious acid in solution; but we have found that, if time is given, its absorbing power is nearly doubled.

On mixing 10 grs. of arsenious acid, dissolved in water, with the properly prepared hydrate of 80 grs. of peroxide of iron, stirring briskly for a few minutes and filtering, not a trace of arsenious acid can be found in the filtered liquid. If the filter, with its contents, be now mixed with a solution of an additional 5 grs. of arsenious acid, and the liquid, after proper stirring, be filtered away, the presence of arsenious acid can be proved in it at once; but if the stirring has been continued for a long time, and twelve hours' contact allowed before filtration, it will be found that the liquid is free from arsenic. On now adding the solution of other 5 grs. of arsenious acid, giving the same care in stirring, and an equal time to the mixture for digestion, it will be found that the filtered liquid gives distinct traces of arsenic, but not more than, on comparison, is given by $\frac{1}{10}$ of a grain of arsenious acid in solution.

The practical inference that seems to be fairly deducible from the experiment here detailed is that, although the hydrated oxide of iron cannot quickly remove more arsenic than one-eighth of the weight of oxide of iron contained in it, yet it continues gradually acting to such an extent that, in the end, it can actually absorb nearly double that quantity.

There is a method of preparing the hydrated oxide of iron as antidote for arsenic, with caustic magnesia in place of either a fixed or volatile alkali; and, as thus prepared, its assimilating power on arsenious acid being complete, and its preparation easy and speedy, it will perhaps be considered by most toxicologists to be the best form of the antidote.

Measure off 307 minims of liquor ferri perchloridi into a glass, dilute with 3 or 4 oz. of water, then rub up, in a mortar, 90 grs. of calcined magnesia, into a cream, with about two ounces of water; this is at once added to the iron solution, and immediately briskly agitated with a glass rod. In about a minute the mixture, previously fluid, sets into a gelatinous mass of hydrate of peroxide of iron, with the production of a slight degree of heat, which on further stirring again becomes thin, and now consists of a mixture of 80 grs. of peroxide of iron, and 142.5 grs. of chloride of magnesium, with a small excess of magnesia. If the case does not contra-indicate the exhibition of chloride of magnesium, the antidote is ready for immediate use; but, if otherwise, it is very easily removed. To get quit of it add 3 or 4 ounces of water, mix and throw the whole upon a muslin or calico cloth laid into a basin, bring together the ends of the cloth, grasping them firmly in the left hand, and with the right press out the liquid steadily and moderately

quick. After the liquid comes in drops, remove the mass from the cloth into a clean mortar, and then rub it into a smooth cream with a little water. The antidote is now ready for use, and is only contaminated with a quantity of chloride of magnesium, altogether insignificant. The whole operation can be easily finished in about five minutes.

If it should be considered necessary to get rid entirely of the chloride of magnesium, filtration can be adopted, and the mixed oxide of iron and magnesia washed till the washings come away tasteless. In consequence of the hydrate being mixed with magnesia, the filtration is very rapid.

It would be a great mistake to think that magnesia itself could act as an antidote to arsenious acid; any one can prove this for himself by the following experiment:—Dissolve a quantity of sulphate of magnesia sufficient to give 80 grs. of magnesia, precipitate with aqua potassæ, filter and wash thoroughly the pulpy hydrate of magnesia; mix now with the magnesia the solution of $2\frac{1}{2}$ grs. of arsenious acid, and, after thorough and continued agitation of the mixture, throw the whole on to a filter; the filtrate will give at once sulphuret of arsenic on acidulation with hydrochloric acid and addition of sulphuretted hydrogen. The same quantity of properly prepared peroxide of iron, in the form of hydrate, would almost at once have removed completely 10 grs. of arsenious acid from solution.

We here introduce a literal translation of Bunsen's original paper, as it has not, so far as we are aware, yet appeared in the 'Pharmaceutical Journal,' and because of its value and brevity.

"Göttingen, May 1, 1834.

"It is long since I have been led to the observation that a solution of arsenious acid is precipitated in a manner so complete by the hydrated peroxide of iron recently precipitated and suspended in water, that a current of sulphuretted hydrogen directed through the liquid, filtered and acidulated with a small quantity of hydrochloric acid, no longer presented the least trace of arsenious acid. I have also found that if to this body some drops of ammonia be added, and if it then be digested at a gentle heat with arsenious acid reduced to an impalpable powder, it transforms this last substance very quickly into a basic arsenite of peroxide of iron, which is altogether insoluble. A series of experiments, founded on this observation has produced in me the firm conviction that this body combines the most favourable conditions as an antidote against the poisonous action of arsenious acid, both in a solid state and in solution. Dr. Berthelot has very willingly, at my request, acted in concert with me in the examination of this subject under all its aspects, and in making it the object of more careful experiments.

"The results of this examination have gone much beyond our expectations, and have confirmed our persuasion that the hydrate of peroxide of iron is a better antidote for arsenious acid, both solid and dissolved, than albumen is for corrosive sublimate.

"Young dogs, less than a foot in height, to which we had given from 4 to 8 grains of arsenious acid reduced into fine powder (and after exhibition of the hydrate, a ligature having been applied to the œsophagus to prevent vomiting), lived more than a week, without presenting, either during life or on dissection, the slightest trace of arsenical poisoning.

"The excrements—which were, as might have been expected from the complete deprivation of both meat and drink, in very small quantity—contained almost the whole of the arsenious acid, in the form of basic arsenite of peroxide of iron, but contained not a trace of free arsenious acid. We have convinced ourselves, by experiments on animals, that a quantity of hydrate of Fe_2O_3 , answering to from 2 to 4 drachms of Fe_2O_3 , mixed with 16 drops of ammonia, is sufficient to transform in the stomach 8 to 10 grs. of well powdered arsenious acid into insoluble basic arsenite.

"It is, besides, easy to see that we might, in cases of poisoning by arsenic, administer this body in proportions much more considerable, with or without ammonia, either by the mouth or by injection, since the hydrate of Fe_2O_3 , being a body altogether insoluble in water, exercises absolutely no action on the animal economy."

The ammonia above recommended by Bunsen can be of no use unless there

should be acid in the stomach, and if this should be considerable, the small quantity of ammonia that could be given would go but a short way in neutralizing the free acid. It would, in our opinion, be better for the medical man to counteract the interfering action of the free acid by the liberal use of calcined magnesia, or a sufficient excess of the hydrated peroxide of iron. Should vomiting have occurred, the action of the vomited matter on test paper would be a useful guide to the medical man.

Although the absorbing power of the hydrated oxide upon arsenious acid is much lower than was found by us, it would be safest to fix the quantity to be used, in any case of poisoning by arsenic, on Bunsen's suggestion.* Soubeiran and Miquel found that dogs to which 12 grs. of white oxide of arsenic had been given died in about two hours, but other dogs that had got 18 grs. of arsenious acid along with twelve times that quantity of peroxide of iron in the state of hydrate, recovered completely. Vomiting was prevented in all cases by the application of a ligature to the œsophagus.

Soubeiran and Miquel have found that at the least twelve times the quantity of peroxide of iron in the form of hydrate is required to destroy the poisonous effects of one part of arsenious acid supposed to have been taken.

Dr. Brett's paper, in the fifteenth volume of the 'Medical Gazette,' containing a denial of the antidotal power of hydrated peroxide of iron on arsenic, is of no value; the experiments are altogether fallacious,—the conditions laid down by Bunsen having been so completely departed from, that he could have been told beforehand, by that *savant*, that the results of the experiments were nothing else than what were to have been anticipated.

For instance, 10 grs. of hydrated peroxide of iron were used along with 2 grs. of arsenious acid; whereas ten times the amount of the arsenious acid supposed to have been taken is the quantity of peroxide of iron, in the form of hydrate, declared by Bunsen to be necessary to remove the poison; and if by the 10 grs. are meant (for his meaning is not very clear) 10 grs. of peroxide of iron in the form of hydrate, in place of 10 grs., there should have been 20 grs., double the quantity used by Dr. Brett. If he used only 10 grs. of the hydrate (and weighed in that state), the quantity was actually between forty and fifty times too small.

His other experiments are equally fallacious, in either using ordinary oxide of iron, or the chemical compound of arsenite of iron, produced by double decomposition between an alkaline arsenite and a persalt of iron, neither of which had Bunsen ever stated to have any antidotal action. If the antidotal action of hydrated peroxide of iron depends on the formation of an insoluble arsenite, it must be an exceedingly basic compound, containing somewhere about 10 equivalents of Fe_2O_3 to 1 equivalent of As_2O_3 . A compound of such a nature must have been obtained in the filter by Dr. Brett on washing the arsenite of iron, and continuing the washing till no more arsenic could be detected in the washing water. The oxide of iron after this operation still contained arsenic.

While engaged in these experiments on the antidotal action of hydrated oxide of iron on the poisonous effects of arsenic, the remarkable case of Dr. Pritchard had just occurred; and it at once occurred to us, that there was a great likelihood, principally from the many chemical relations of antimony to arsenic, that the hydrated oxide of iron might also be an antidote to the poisonous action of antimony.

* One of the writers of this paper has reason to entertain grateful feelings in connection with Bunsen's antidote, as he probably owes his life to the prompt use of it, along with other means, after having, by an awkward mistake, swallowed a poisonous dose of Donovan's solution.

A few experiments soon confirmed, in the fullest manner, our anticipations. A mixture of solution of perchloride of iron, containing 80 grs. of anhydrous peroxide of iron and a solution of 1 oz. avoirdupois of crystallized carbonate of soda, was prepared; to this mixture, containing hydrated peroxide of iron and chloride of sodium, was added a solution of 10 grs. of tartar emetic: the whole was thoroughly agitated, and thrown on a filter. The filtered liquid, acidulated with muriatic acid, was tested with sulphuretted hydrogen for antimony, but not a trace was found. The filter, with its contents, was then mixed with other 10 grs. of tartar emetic, which were again removed by the oxide of iron. A third quantity of tartar emetic added was almost entirely removed, so that 80 grs. of hydrated peroxide of iron absorb nearly 30 grs. of tartar emetic from solution.

The absorbing action of hydrated oxide of iron towards antimony would be still more striking but for the dissolving power of the tartaric acid, set free, upon the peroxide of iron. That the oxide of iron does not merely act by taking the organic acid and precipitating the oxide of antimony in an insoluble state, is shown by using hydrate of magnesia instead. In this case, even with a much smaller quantity of tartar emetic, the filtered liquid gives antimony in abundance to the proper tests.

To be suitable for the antidotes, the liquor ferri perchloridi must answer to the following tests:—one fluid drachm must contain 15·62 grains peroxide of iron, ammonia must give a pure reddish-brown precipitate, without any shade of black; it must not smell strongly acid, nor, after slight dilution, give a brisk effervescence with a piece of zinc.

Directions proposed to be attached to each bottle of Liq. Ferri Perchloridi:—

Prussic acid antidote.—Take of liquor of perchloride of iron 37 minims, protosulphate of iron in crystals, as pure as possible, 25 grs.; as much water as make a solution of a protosesquisalt of iron, measuring about half an ounce. Dissolve, on the other hand, 77 grs. crystallized carbonate of soda in about half an ounce of water. These quantities destroy the poisonous action of between 100 and 200 minims of medicinal prussic acid, official strength, on giving first the one liquid and then the other.

Antidote for cyanide of potassium.—The antidote for this compound is the same as for prussic acid, except that the solution of protosesquisalt of iron is to be used without the alkaline solution, the prussic acid being already combined with an alkali; the use of the alkali, however, would not be injurious; a harmless yellow prussiate would be formed. In this case, in consequence of the possible presence of free acid in the stomach, the alkaline liquid should be given first,—the quantities given, as the prussic acid antidote would decompose 35 grains of cyanide of potassium.

Antidote for arsenious acid.—Measure out 5 fluid drachms and 7 minims of liquor ferri perchloridi into 2 or 3 oz. of water, then add to the liquid a solution of 1 oz. of crystallized carbonate of soda in a few ounces of warm water, stir till effervescence ceases; the resulting mixture destroys about 10 grs. of arsenious acid.

Antidote for tartar emetic.—Mix 5 fluid drachms and 7 minims of liquor ferri perchloridi with a few ounces of water; mix in now a cream formed of 90 grs. of calcined magnesia, rubbed up with water in a mortar, stir till, after gelatinizing, the mixture again gets thin; empty the mixture into a calico or muslin cloth, and press out the liquid; remove the mass from the cloth into a clean mortar, and rub it up with a little water into a smooth cream; in this state it can destroy upwards of 20 grs. of tartar emetic. It may also be used as an antidote for arsenious acid, of which it absorbs about 10 grs.

SUPPLEMENT TO PAPER
ON AN ANTIDOTE AT ONCE FOR PRUSSIC ACID,
ANTIMONY, AND ARSENIC.

BY MESSRS. T. AND H. SMITH.

In addition to and completion of our late remarks, in this Journal, on Sol. Ferri Perchloridi as an antidotal agent in poisoning by either prussic acid, antimony, or arsenic, it occurred to us, while our manuscript was in the compositors' hands, that the question may be asked—what effect would the not unlikely occurrence of free acid in the stomach have on the action of the prussic acid antidote when its use may be indicated? If the amount of acid could be known, the answer would be easy, viz. the corresponding quantity of an alkali given in advance would prevent any interference with the desired action; but a quantity of alkali so great would be required to meet the most extreme case that the remedy might itself have an injurious action, or might form a soluble yellow prussiate which, although not poisonous, would be a less desirable product than the insoluble and inert Prussian blue. It therefore suggested itself to our minds that caustic magnesia might be a more desirable agent in such a case. A single trial showed that every difficulty is removed by the use of that substance, and that it does not interfere with the action of the antidote.

Ninety grains of calcined magnesia were made into a smooth cream with a little water; two drachms of muriatic acid were then added, and the acid was instantly neutralized, yet leaving a large excess of magnesia. 100 minims of medicinal prussic acid were now added, and on now preparing to add the alkaline solution to form a cyanide, before the addition of the iron solution, it occurred to us that the excess of magnesia itself might form the cyanide necessary to the formation of the Prussian blue. Resolving, therefore, to put the idea to the test, we at once added the iron solution, and the moment contact between the two liquids occurred the blue colour showed that the formation of Prussian blue had, to a certain extent, been the result. After the addition of a solution containing $11\frac{1}{2}$ minims of solution of perchloride of iron, and $8\frac{1}{4}$ grains of green vitriol, muriatic acid was added till the excess of magnesia and the excess of proto-peroxide of iron had been dissolved. Prussian blue was left in abundance. On now at once filtering, and adding to the filtered liquid a few drops of a solution of persalt of iron, no Prussian blue was formed,* showing the

* When freshly-precipitated Prussian blue is rubbed up with calcined magnesia in considerable excess, after a short time, the mixture having been collected upon a filter and washed

LIQUOR PERCHLORIDI FERRI.

DIRECTIONS for using this as an Antidote to Prussic Acid, Cyanide of Potassium, Antimony, and Arsenic.

For **PRUSSIC ACID** and **CYANIDE** of **POTASSIUM**:—make into a smooth cream, with water, two drachms of calcined magnesia. Give the emulsion to the patient, then give, in water, a solution of sixteen minims of solution of perchloride of iron, and twelve and a half grains of green vitriol.

For **ARSENIC**, and **TARTAR EMETIC**:—mix five fluid drachms and seven minims of solution of Perchloride of Iron with a few ounces of water; mix in now a cream formed of ninety grains of calcined magnesia, rub up with water in a mortar, stir till, after gelatinizing, the mixture again gets thin; give the mixture as it is.

For further information see *Pharmaceutical Journal* for October and November 1865 on an antidote at once for Prussic Acid, Antimony, and Arsenic, by T. and H. SMITH, 21 Duke Street, Edinburgh, and 69 Coleman Street, London.

LIQUOR PERCHLORIDI FERRI.

DIRECTIONS for using this as an Antidote to Prussic Acid, Cyanide of Potassium, Antimony, and Arsenic.

For **PRUSSIC ACID** and **CYANIDE** of **POTASSIUM**:—make into a smooth cream, with water, two drachms of calcined magnesia. Give the emulsion to the patient, then give, in water, a solution of sixteen minims of solution of perchloride of iron, and twelve and a half grains of green vitriol.

These proportions are in excess of the theoretical quantity for one hundred minims of medicinal Prussic Acid, or an equivalent quantity, about eight grains, of commercial Cyanide of Potassium, but they are on the safe side. Should it be supposed that twice or more times that quantity of the poison has been taken, of course twice or more times the quantity of Iron should be given, but the Magnesia remains the same,

For **ARSENIC**, and **TARTAR EMETIC**:—mix five fluid drachms and seven minims of solution of Perchloride of Iron with a few ounces of water; mix in now a cream formed of ninety grains of calcined magnesia, rub up with water in a mortar, stir till, after gelatinizing, the mixture again gets thin; give the mixture as it is, or, if advisable, empty the mixture into a calico strainer, and press out the liquor, then remove the mass into a mortar, and rub it up, with a little water, into a smooth cream. In this state it can destroy upwards of twenty grains of Tartar Emetic, or ten grains of Arsenious acid.

Carbonate of soda, (washing soda,) answers instead of Magnesia, but it is not advisable in the case of poisoning by Tartar Emetic, because the Stomach, in such a case, is very irritable, and the Chloride of Sodium, formed, would increase that irritability unnecessarily.

If, however, washing soda only is at hand, it should be used instead of the Magnesia, by simply adding one ounce of it in solution to the solution of perchloride of iron, and giving the mixture, (after stirring and cessation of effervescence, to the patient.

For further information see *Pharmaceutical Journal* for October and November 1865 on an antidote at once for Prussic Acid, Antimony, and Arsenic, by T. and H. SMITH, 21 Duke Street, Edinburgh, and 69 Coleman Street, London.

absence of any ferro-prussiate. On now adding aqua potassæ to neutralize the excess of acid and throw down the iron in solution, no tinge of blue was produced, not even on adding an excess of dilute muriatic acid. The precipitate entirely dissolved to a clear solution. The complete absence of prussic acid was thus proved. All of it had been completely removed.

We prepared as above another quantity of magnesia emulsion mixed with prussic acid, and, after adding the iron solution, the liquid, having been filtered from the mixture, was without delay distilled, and on testing the distillate, it neither answered to the Prussian blue nor to the silver test; it contained no prussic acid.

We believe ourselves justified in now giving, as the antidote for prussic acid, magnesia and a proto-persalt of iron, thus:—Make into a smooth cream, with water, from 1 to 2 drachms of calcined magnesia. Give the emulsion to the patient, then give, in water, a solution of 16 minims of perchloride of iron, and $12\frac{1}{2}$ grains of green vitriol. These numbers, being in excess of the theoretical quantity, were those used in our experiments. Should it be supposed that so much as 400 minims medicinal prussic acid had been taken, of course four times the quantity of the iron compound necessary for 100 minims should be given, but without altering the quantity of magnesia.

Although calcined magnesia, *alone*, slowly dissolves in prussic acid, yet in the presence, simultaneously, of a large excess of magnesia and the solution of a proto-persalt of iron, the reciprocal action resulting in the formation of a Prussian blue seems to be almost instantaneous.

with distilled water, it will be found that almost all the Prussian blue has been converted into proto-peroxide of iron, along with a simultaneous corresponding formation of ferrocyanide of magnesium, as may be proved by the addition of a solution of a persalt of iron to the filtered liquid, whereby almost all the Prussian blue is reproduced. This reaction does not take place when an excess both of magnesia and of the iron solution is used, as in the case of the antidote; for, if the mixture of Prussian blue, proto-peroxide of iron, and magnesia thus obtained be digested for a long time with water, and that at the temperature of the living body, barely a trace of Prussian blue is produced upon the application of a solution of persalt of iron to the filtrate. In this case the excess of iron in the form of precipitated oxide, along with the Prussian blue, appears to prevent the Prussian blue from being decomposed by the magnesia, as would occur with this substance by itself. Two explanations of this remarkable result suggest themselves: either a compound, stable towards magnesia, may be formed between the Prussian blue and the proto-peroxide of iron, or this last substance by enveloping, and thus shielding the Prussian blue from the action of the magnesia, may prevent the result that would otherwise be produced.

